40 Thorndike Street – Cambridge, MA
Glare Potential Analysis - FINAL REPORT
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SUBMITTED TO

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Figure 1: 3D Computer Model of the 40 Thorndike neighborhood

1.0 Executive Summary – Scope of Study

- RWDI conducted a solar reflection and glare potential analysis for the grade level area surrounding the proposed building at 40 Thorndike Street.

- This study was conducted to determine the general impact of reflected sunlight from the updated building design.

1.1 Executive Summary – Examples of Buildings With Shapes that Cause Unwanted Reflected Light Problems

It is a common experience in urban areas of cities to occasionally experience reflected light from glass and metallic surfaces of vehicles on the road and some buildings. Most of the time impacts of reflected light are not a significant concern.

Examples of buildings that have caused reflected light impacts of concern are shown below. These buildings have either a concave shape (e.g., 1, 2) which focuses the light to a small region at intensities greater than the incident light levels at certain times of the year and times of day, or the building has a convex shape (e.g., 3) which causes frequent short duration impacts.

(1)

Image of Vdara Tower, Las Vegas
Ref: http://en.wikipedia.org/wiki/File:Vdara2010.JPG

(2)

Image of Walkie Talkie Tower, London, England
http://en.wikipedia.org/wiki/File:20_Fenchurch_Street,_City_of_London.jpg

(3)

Image of Museum Tower, Dallas, Texas
http://www.skyscrapercenter.com/building.php?building_id=2700

1.2 Executive Summary – Overview of findings for this project

The proposed re-clad 40 Thorndike tower does not have concave or convex shape that would have the concerns raised on the previous slide. This means that there is no potential for multiple reflections to converge at a single point, creating a "hot spot". As well, the low reflectance values of the glazing help to limit reflection intensity for most solar positions.

Frequent reflections from 40 Thorndike will occur on the area of Spring Street directly south of the building. However due to the lack of reflection focusing, the low reflectivity nature of the glazing and the downward angles at which they will be reflecting from, these reflections are not expected to significantly impact an individual's ability to see, nor are they expected to lead to heat gain issues on the nearby buildings.

A glancing reflection from the north façade of the tower during the early morning hours will occur along Thorndike Street. Given the current direction of travel on Thorndike, this means that drivers will be looking towards the reflection, however given that the sun will already likely be in the drivers field of vision, the extra reflected light is not expected to significantly change a driver's ability to see.

Reflections from the west façade may also impact along Thorndike in the evening hours, but these will be less intense, due to the glazing's low reflectivity.

Overall, the results presented in this report show that generally the planar (flat) characteristic of the facades of the building help to scatter light rather than focusing it, thereby minimizing the impact of reflected light in the neighborhood.

Figure 2: Schematic diagram showing the study building location and surroundings

Figure 3: Glazing type distributions

2.0 Methodology

Generally speaking, the three most important factors that describe the impact of glare are:

- Frequency (how often glare events occur)
- Intensity (how “bright” the events are, based on a combination of solar intensity, surface size and orientation, and the distance from the point of interest)
- Duration (how long each instance of glare lasts)

RWDI assesses these issues using a computer modeling tool developed in-house. It is designed to accurately assess glare potential.

- First, a 3D model of the area of interest is generated, and subdivided into many smaller triangular patches as shown in Figure 4. The reflective properties of the various surfaces are defined, in this case using the data presented in Appendix A.
- Then, for each hour in a year, solar position is computed, “virtual rays” are then drawn from the sun to each triangular patch of the 3D model.
- Each ray that is un-obstructed is reflected from the building surface onto a horizontal plane receiving surface just above street level.
- Based on historic solar radiation data taken from a published climate file, the angle of contact the ray makes with the surface, and any obstructions it encountered on its path from sun to the receptor point, a net intensity is computed.
- As well, the potential for this light to cause physical effects to a viewer is then computed using a methodology created by Sandia National Labs[1].
- Then a statistical analysis is performed to assess how often glare instances occur, their intensity and duration.

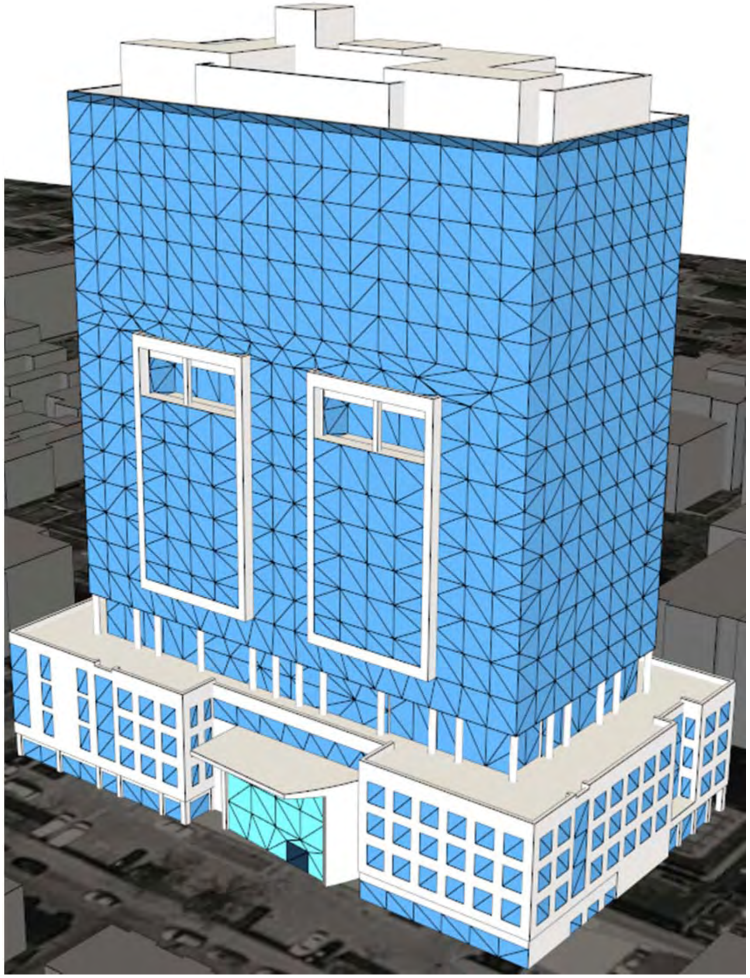


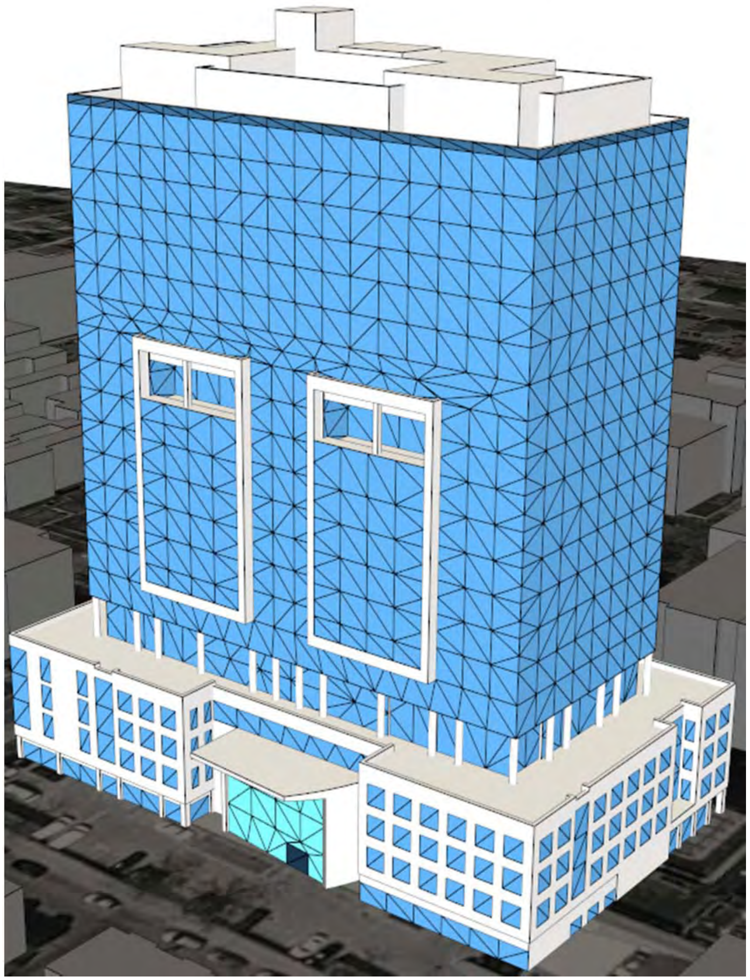
Figure 4: 3D model of 40 Thorndike showing surface subdivisions

[1]Ho, C.K., C.M. Ghanbari, and R.B. Diver, 2010, Methodology to Assess Potential Glint and Glare Hazards from concentrating Solar Power Plants: Analytical Models and Experimental Validation, SAND2010-2581C, in proceedings of the 4th International Conference on Energy Sustainability, ES2010-90053, Phoenix, AZ, May 17-22, 2010.

2.1 Methodology

The results from the computer model are presented as color plots. This information is useful for a screening-level assessments (Level 1) as presented in this report which presents predicted glare potential. It is also useful to identify any areas that may require a more detailed analysis, called a Level 2 analysis.

If a Level 2 analysis is warranted, the software is capable of performing a more detailed simulations in space and time. For example, reflections can be modeled at small time steps of between 1 to 5 minutes over a year, thereby able to show possibilities of brief glare instances (glint).



Key simplifications of the modeling include:

- Only sunlight reflected from the project building is included in the analysis;
- No modeling of light reflections from other buildings and vehicles;
- No modeling of vegetation. This is important as tree can be beneficial at intercepting reflected light during summer months, of course depending on the viewer location.

The modeling results are presented in the following pages.

[1]Ho, C.K., C.M. Ghanbari, and R.B. Diver, 2010, Methodology to Assess Potential Glint and Glare Hazards from concentrating Solar Power Plants: Analytical Models and Experimental Validation, SAND2010-2581C, in proceedings of the 4th International Conference on Energy Sustainability, ES2010-90053, Phoenix, AZ, May 17-22, 2010.

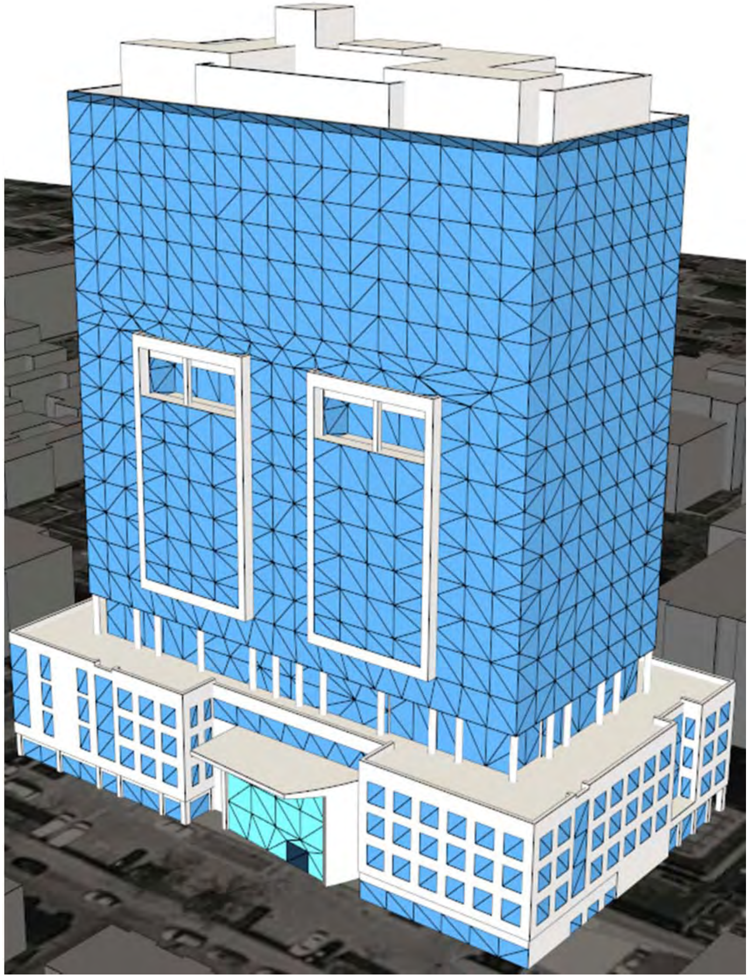
3.0 Results - Reflection Intensity

The modeling results are presented in the following pages.

The plots show the predicted average intensity of reflections in neighborhood over a horizontal plane at pedestrian height (about 5 feet above grade). The average value plots indicate areas that are subjected to frequent reflections from one or more sources.

The predicted maximum values have also been assessed. These values are used to check for effects related to glancing reflections (which will retain almost all of their original intensity) and also for areas where multiple reflections converge (i.e., hot spots).

RWDI looks for any areas in which both maximum and average reflected sunlight intensities are high as these would be a significant concern which would warrant further detailed study. We did not find this concern in this study of 40 Thorndike.



3.1 Modeling Results - Average Reflection Intensity at Pedestrian Level

Figure 5 presents the predicted average reflected direct solar radiation from the re-clad 40 Thorndike building from an hourly analysis for a typical year of the Boston climate.

Areas with the highest average radiation are found immediately south of the building on Spring Street. This is due to frequent reflections from the south façade of 40 Thorndike.

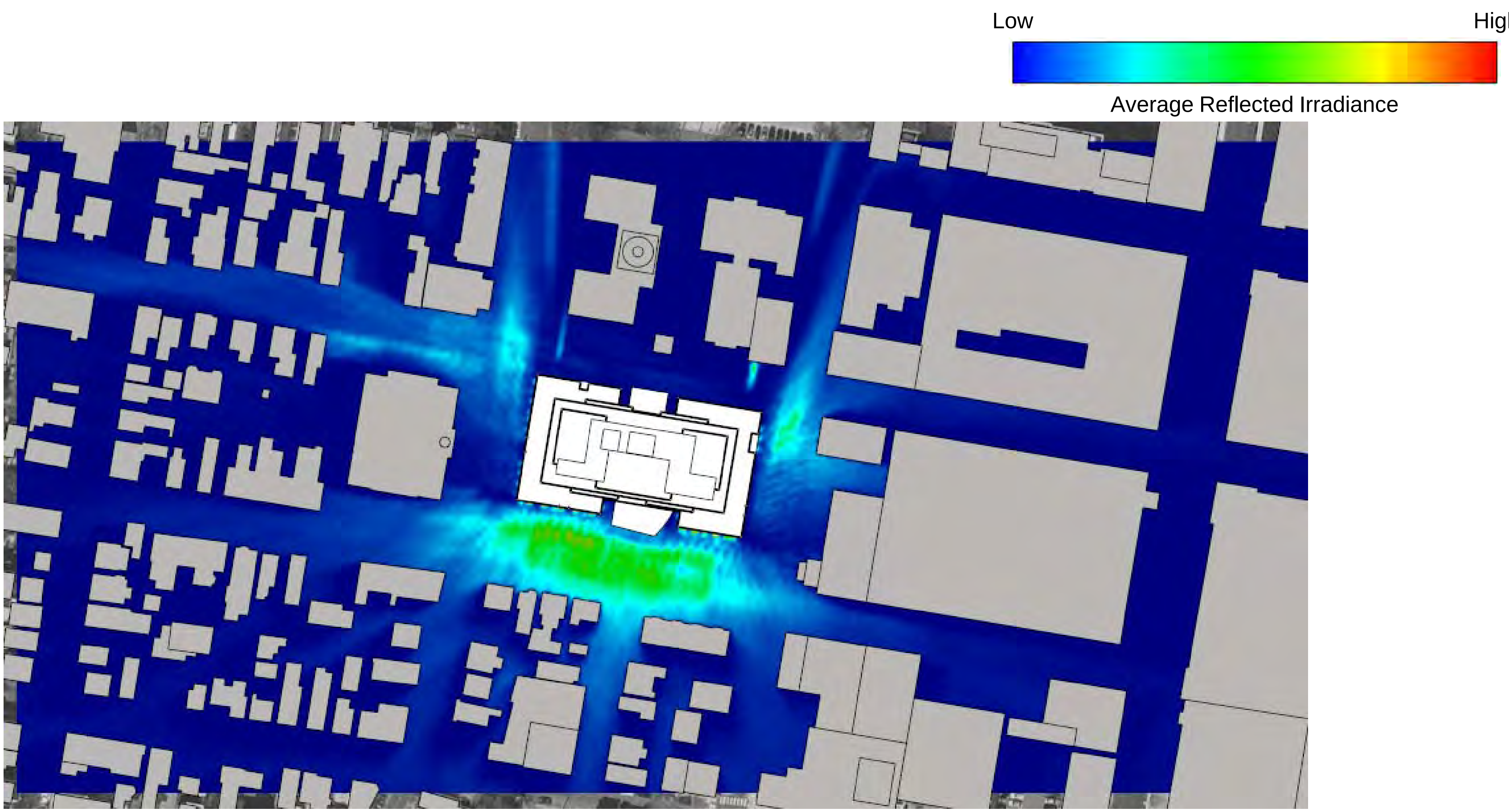


Figure 5: Results of the average reflection intensity analysis for the Surrounding Neighborhood

3.2 Modeling Results - Maximum Reflection Intensity at Pedestrian Level

Figure 6 is the same as Figure 5 showing the distribution of average intensity reflected light , with the addition of labels identifying areas that that would receive relatively short duration peak intensity reflected sunlight.

Areas to the west of the project at points 1 and 2 along Thorndike will receive the most intense reflections. These peak values correspond to glancing reflections from the north façade of the tower during early mornings in the summer months. Given the direction of travel for cars on Thorndike, drivers will generally be looking directly at the reflections at those times. However given that the drivers will already be facing the early morning sun the additional reflected light is not expected to change the driver's visual experience.

Areas 4 and 5 will receive moderate intensity reflections periodically in the morning.

Areas 3 and 6 will receive moderate intensity reflections mid-morning and mid-afternoon for relatively short durations

Area 7 is expected to receive moderate reflections late afternoon, owing to glancing reflections off the south face of the building.

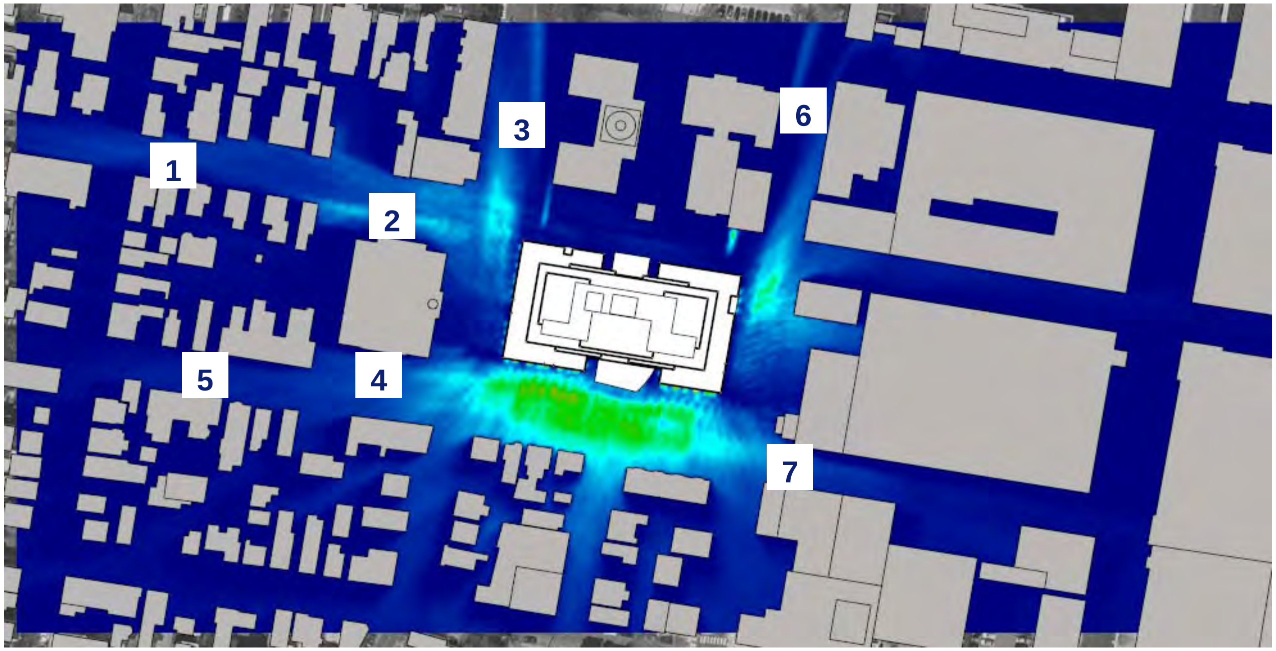


Figure 6: Results of the maximum reflection intensity analysis for the Surrounding Neighborhood

3.3 Modeling Results - Reflection Frequency at Pedestrian Level

The results presented on the following page illustrate the predicted percentage of day-time hours where significant reflections occur on a plane at pedestrian level. In this context "significant" means that the reflection is large enough (in terms of brightness or physical size), or close enough to the point in question that the reflection could cause distracting after images to an unprotected viewer (i.e., where an after image has a short-term affect on an person looking directly at the point of glare such as that of a flash from a camera).

This frequency *does not* mean that a point is in glare for an entire hour, rather it means that for a given time and date, the sun is in a position that reflects light onto the point. This is an intentionally conservative method of assessing the potential for glare to account for the wide variation in how an individual reacts to light.

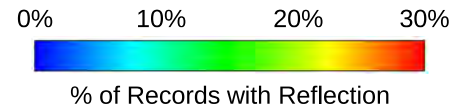
Prediction of frequency of significant light reflections would also depend on the selection of glazing for the façade. The current model uses the properties presented in Appendix A which are about as low a reflectance as is available on the market . This is a positive design feature of the proposed cladding.

3.3 Modeling Results - Reflection Frequency at Pedestrian Level

Figure 7 presents the predicted frequency of all significant sunlight reflections from the proposed 40 Thorndike building.

Generally, the surrounding neighborhood will experience some reflections from the building with the areas immediately to the south, west and east of the building experiencing the most frequent reflections.

The reflections to the south of the building will occur from late morning to late afternoon, with the reflected light extending further from the building in the winter months when the sun is lower in the sky. The reflections from the east and west facades are likely restricted to the morning and evening hours and will be more frequent in summer when the sun is above the elevation of the surrounding buildings more often.



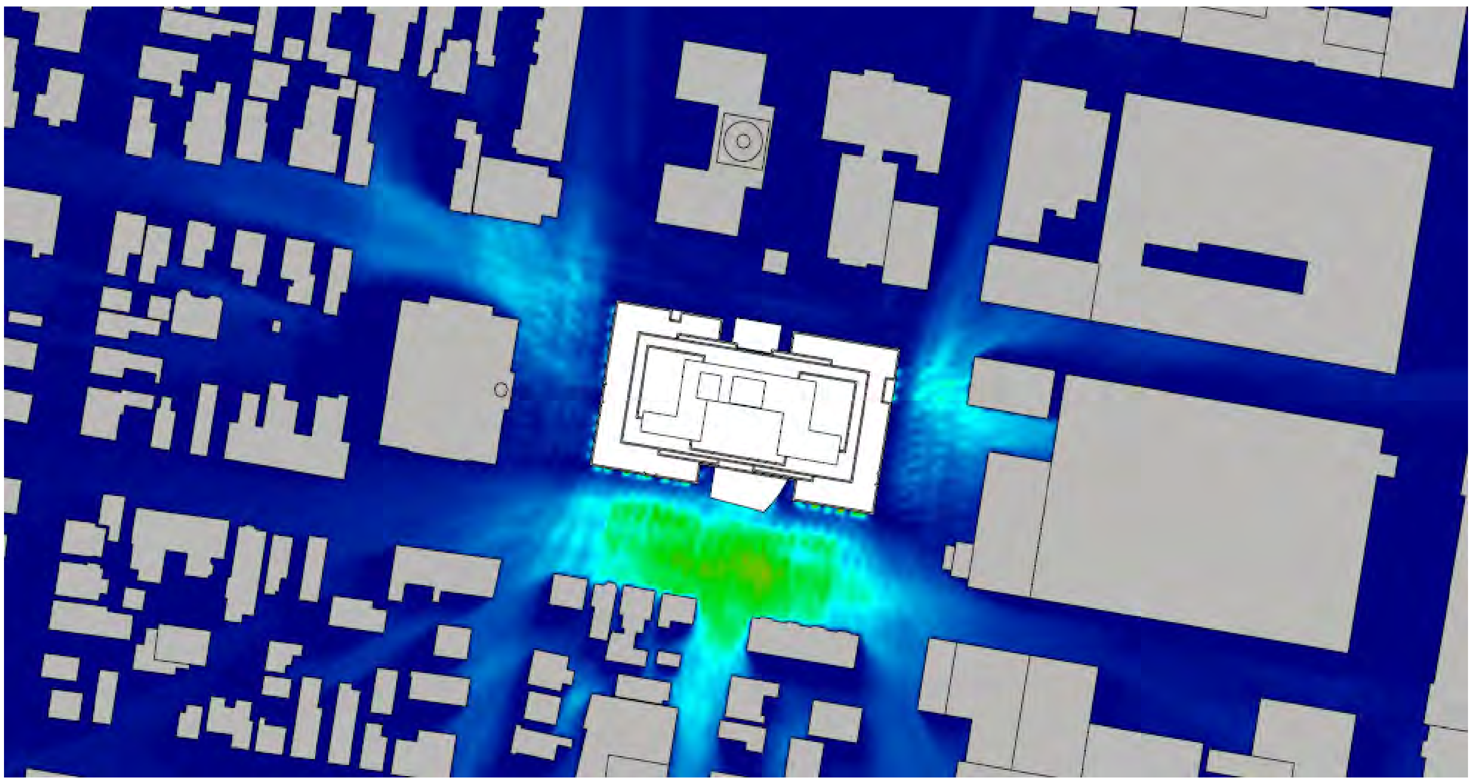


Figure 7: Results of the reflection frequency analysis for the Surrounding Neighborhood

4.0 Conclusions

The following are RWDI's conclusions from this Level 1 computer model study:

1. Generally speaking, the impact of reflected sunlight from the proposed 40 Thorndike building on the surrounding neighborhood is relatively low and likely comparable to a common experience of living and working in a typical urban environment.
2. The most intense reflections are the least frequent and the more frequently occurring reflections are lower in intensity.
3. There is no indication of any light focusing or reflection effects that pose a significant concern to pedestrians, drivers or property.
4. Relatively frequent solar illumination is predicted on part of Spring Street directly south of the building. However given that the reflections will be angled downward and are not focused in any way, they are unlikely to cause concerns for residents and drivers to see. As well, since the peak values are low in this area the frequent reflections are unlikely to lead to heat buildup issues.
5. Certain areas, particularly northwest of the building on Thorndike and Third Streets will likely encounter intermittent reflections but these are not expected to impair driving in a significant way, primarily because the reflected light is predicted to occur at shallow angles of incidence for which the viewer would likely experience glare from the sun directly during clear sky conditions.
6. There are certain locations where the areas of relatively high maximum reflected irradiance appear to be interrupted by nearby buildings. This could mean that there will be intermittent reflections from 40 Thorndike onto those buildings. For some people the additional light will be satisfactory. For others it may cause them to close blinds or other shading devices of their residence, or adjust their direction of view during that period of time.
7. The effect of the trees which line the local streets have not been included in this study as a conservative measure. When the trees have foliage they will intercept some light reflections as they normally do in shading direct sunlight.

Appendix A - Building Façade Glass Properties

Façade material details were assigned using information provided by Elkus Manfredi on January 1, 2014. Four primary glazing types were identified:

- G1: Typical clear vision glass with Viracon VE1-2M on surface 2 (R_{out} = 10%)
- G2: 2 layers of ¼" Clear glass with Clear Sentry Glass Plus PVB interlayer (R_{out} = 8%)
- G3: 12mm Low Iron outer lite (Optiwhite), 16 mm air space, 6 mm Low Iron inner lite (Optiwhite), ProT 70/40 Low E on #2 (R_{out} = 10%)
- G4: ¼" Low Iron Glass outer lite (Starfire), VE-1-2M on Surface #2, ½" air space, ¼" Low Iron inner lite (Starfire) (R_{out} = 10%)

Figure 8: Glazing type distributions